FROM: HQ AFCESA/CES
139 Barnes Drive
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SUBJECT: **Engineering Technical Letter (ETL) 97-12: Mitigation of Existing Building Structural Deficiencies for Seismic and High Wind Loads**

**1. Purpose.** This ETL provides guidance to help the Base Civil Engineer (BCE) and other users establish minimum standards of performance to mitigate structural deficiencies in Air Force buildings subject to seismic events and high winds.

**2. Application.** All Air Force installations.

**2.1.** Authority. Presidential Executive Order 12941*, Seismic Safety of Existing Federally Owned and Leased Buildings*.

**2.2.** Effective Date: Immediately. Expires five years from date of issue.

**3. Referenced Publications.**

**3.1.** AFJMAN 32-1049V3*, Seismic Design Guidelines for Upgrading Existing Buildings* (previously AFM 88-3, Chap 13).

**3.2.** ETL 97-10, *Structural Evaluation of Existing Buildings for Seismic and Wind Loads.*

**3.3.** Federal Emerency Management Agency (FEMA) 178, *NEHRP Handbook for Seismic Evaluation of Existing Buildings*, June 1992.

**3.4.** FEMA 273, *NEHRP Guidelines for the Seismic Rehabilitation of Buildings (Ballot Version)*, September 1996.

**3.5.** 1996 National Seismic Hazard Maps, U.S. Geological Survey, 15 Nov 96, 10% Probability of Exceedance in 50 Years, 0.2 sec Spectral Acceleration (http://wwwneic.cr.usgs.gov/eq/finmaps.shtml).

**3.6.** ASCE 7-95, *Minimum Design Loads for Buildings and Other Structures,* (ASCE 7-95 a revision of ANSI/ASCE 7-93), American Society of Civil Engineers (ASCE), 1996.

## 4. Definitions.

**4.1.** *High Seismic Zone*: Building site for which the EQ-II (basic design earthquake), 10%/50 years for Soil Profile Type B, spectral acceleration in the short-period range ($S_{DS}$) is equal to or greater than 50 percent. Included in this category within the continental United States are Eielson AFB, Elmendorf AFB, March ARB, Los Angeles AFB, Travis AFB, Vandenberg AFB, and McChord AFB.

**4.2.** *Moderate Seismic Zone*: Building site for which the EQ-II $S_{DS}$ (see para 4.1) is equal to or greater than 16 percent but not more than 50 percent. Sites in the U.S. include Beale AFB, Charleston AFB, Edwards AFB, Hickam AFB, Hill AFB, Kirtland AFB, McClellan AFB, Mountain Home AFB, Nellis AFB, Scott AFB, and Shaw AFB.

**4.3.** *Low Seismic Zone*: Building site not in the high or moderate zones.

**4.4.** *High Wind Region*: Building site where the basic wind speed, V, as determined from Figure 6-1, ASCE 7-95, is greater than or equal to 177 km/h (110 mph) or the site is located within 161 kilometers (100 miles) of the hurricane oceanline. These regions include areas vulnerable to hurricanes, such as the U.S. Atlantic and Gulf Coasts, Hawaii, Puerto Rico, Guam, Virgin Islands, and American Samoa as defined in Table 6-4, ASCE 7-95. Overseas, high wind region installations include those with comparable wind hazards based upon regional design criteria or climatic data.

**4.5.** *Partial Rehabilitation*: Rehabilitation that corrects deficiencies for only part of the lateral-force-resisting systems of the total structure. Specific structural elements or components are selected for rehabilitation to reduce risks related to specific severe vulnerabilities. Individual components or elements may be rehabilitated to a specific force resistance provided that the rehabilitation does not adversely affect other components or elements. To meet the definition of partial rehabilitation, rehabilitation procedures must provide for a total load path to resist lateral force.

**4.6.** *Primary Structural Elements or Components*: Elements or components that enable the structure to resist lateral forces. Only limited degradation of lateral-force-resisting stiffness and strength is permitted for the basic design loads.

**4.7.** *Secondary Structural Elements or Components*: Elements or components other than the primary elements and components. Substantial degradation of the lateral force-resisting stiffness and strength is permissible for the basic design load as long as such degradation does not impair the integrity of the primary system and the component or element will still support the gravity loads.

## 5. Requirements.

**5.1.** Objective of Structural Mitigation. A building subjected to seismic and high wind hazards may be expected to incur significant and costly damage. The objective of mitigation is to assure that the primary structure will not collapse or threaten the lives and safety of its occupants. The primary structure must provide for a continuous load path of adequate strength and stiffness to transfer lateral loads. To attain this goal, apply rehabilitation to the specific components or elements designed to resist the basic lateral load. After mitigation, check the primary lateral force resisting system for collapse prevention in case of a rare but stronger event. Partial rehabilitation is permitted if a primary system is in place which will resist the expected lateral loads. In such a case, the failure of secondary structural elements during an event may cause injuries, but the expected risk of life-threatening injury is very low.

**5.2.** Steps for Structural Mitigation:

**5.2.1.** Determine Partial or Complete Rehabilitation. Existing buildings must meet or exceed new building criteria and standards for complete rehabilitation. Buildings considered irregular in either plan or elevation may be rehabilitated by component or element upgrading (partial rehabilitation) only if the building is less than two stories high and ells can be separated using seismic joints or eliminated from the elevation. Partial rehabilitation will be used only for structures of the common building types given in FEMA 178, and will not be used for buildings that are a combination of building types. Partial rehabilitation mitigation schemes will not be used to correct structural deficiencies associated with Building Type 8, Concrete Moment Frame; Type 10, Concrete Frame with Masonry Infill; and Type 12, Precast Concrete Frame.

**5.2.2.** Perform a Detailed Evaluation. Use the loads and procedures specified in ETL 97-10 to evaluate in detail the structural components and elements. Complete the applicable true/false checklists contained in FEMA 178, based upon the common building type, to determine specific deficiencies of structural elements or components. For partial rehabilitation, only primary structural members must undergo detailed evaluation, but secondary members must be checked to assure that integrity.

**5.2.3.** Prepare a Rehabilitation Design. Design for rehabilitation must address the deficiencies identified using the evaluation procedures of ETL 97-10 and FEMA 178. Design loads will be the same as those used to evaluate the respective structural member. To establish compliance with the design objective, evaluate the rehabilitated structural system, using the same evaluation procedures which defined the deficiency. The strengthening of an element or component must not shift the load and/or cause another primary or secondary structural member to fail.

**5.2.3.1** Deficiencies that require mitigation are listed in the following generic matrix. Use this matrix as a template on which to list the actual components or elements of the specific building under consideration. Checked items are mandatory for mitigation when using partial rehabilitation schemes.

| Typical Deficiencies | Seismic Zone | | |
|---|---|---|---|
| | H | M | L |
| Load Path | √ | √ | √ |
| Redundancy | √ | √ | |
| Frames | | | |
| Stress check | √ | √ | √ |
| Drift check | √ | | |
| Strong column weak beam | √ | | |
| Connections | √ | √ | √ |
| Diagonals or bracing | √ | | |
| Shear Walls | | | |
| Shear stress check | √ | √ | √ |
| Openings | √ | | |
| Overturning | √ | √ | |
| Wall reinforcement | √ | √ | |
| Collectors | √ | | |
| Proportions | √ | √ | |
| Diaphragm | | | |
| Openings (reentrant corners) | √ | | |
| Stiffness/strength | √ | √ | |
| Continuity | √ | √ | √ |
| Frame shear transfer | √ | √ | |
| Anchorage to Foundations | √ | √ | |
| Overturning | √ | | |

**Note:** In high wind regions, apply the above criteria for high seismic zones.

**5.2.3.2.** Design and construction is required only for specific severe deficiencies identified by the evaluation and within the matrix for the specific project. The mitigation design for the selected component must be of the same basic style and materials as the existing building. The matrix for the specific building must be developed to attain the basic objective of structural mitigation.

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